

INDUSTRIAL HYGIENE REPORT OF MECHANICAL
COTTON PICKER OPERATOR EXPOSURE TO DEF

At

Belridge Farms
P.O. Box 1852
Bakersfield, California 93303

HS-782 Revised September 19, 1980

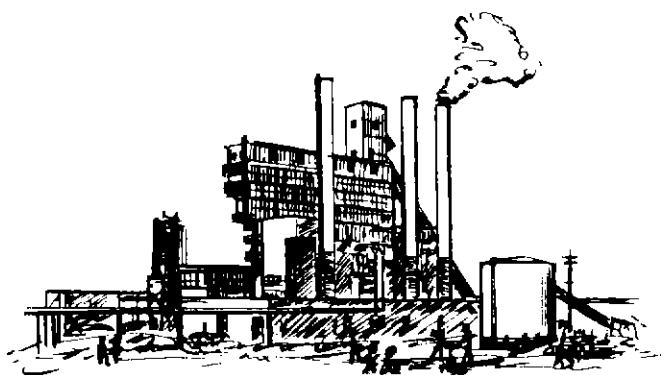
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Division of Pest Management, Environmental
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NIOSH

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

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Mechanical Cotton Picker Operator
Exposure to DEF

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Belridge Farms
P.O. Box 1852
Bakersfield, California 93303

SURVEY CONDUCTED BY:
Dennis Roberts, NIOSH/
Clifford Smith, California Department of
Food and Agriculture

DATE OF SURVEY:
November 15-17, 1978

REPORT WRITTEN BY:
Clinton Cox

DATE OF REPORT:
September 19, 1980

REPORT #:
80.19

Industrial Hygiene Section
Industry-wide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Cincinnati, Ohio

PURPOSE OF SURVEY:

To conduct an in-depth survey of mechanical cotton picking operations in support of the project "Neuropathy and Pesticide Workers". In particular, to characterize mechanical cotton picker operator exposure to DEF, a cotton defoliant.

EMPLOYER REPRESENTATIVE

CONTACTED:

Ken Wiseman, Director of Personnel

EMPLOYEE REPRESENTATIVE

CONTACTED:

Belridge Farms employees are not represented by a labor union.

STANDARD INDUSTRIAL

CLASSIFICATION OF PLANT:

0722

DEF is a registered trademark of Chemagro Agricultural Division, Mobay Chemical Corporation; however, DEF will be used as an abbreviation for s,s,s-tributylphosphorotrithioate in this report.

Use of a manufacturer's name, brand, or trademark does not constitute endorsement by the National Institute for Occupational Safety and Health.

ABSTRACT .

On November 15-17, 1978, NIOSH conducted an industrial hygiene survey of the mechanical cotton picking operations conducted by Belridge Farms in Bakersfield, California. The purpose of this survey was to characterize mechanical cotton picker operator exposure to s,s,s-tributylphosphorotrithioate (DEF), a cotton defoliant. The respiratory samples ranged from 6.9 to 83.4 ng/m³ with a geometric mean of 17.9 ng/m³. The dermal samples ranged from 0.05 to 1.70 mg/8 hours with a geometric mean of 0.16 mg/8 hours. Standards for occupational exposure to DEF have not been established. Since weather conditions were abnormal (i.e. precipitation), additional respiratory and dermal sampling should be conducted during more typical weather conditions which are conducive to higher exposure levels.

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is mandated under Section 20(a)(7) of the Occupational Safety and Health Act of 1970 (PL-91-596) to conduct and publish industry-wide studies of the effects of chronic or low level exposures to industrial materials, processes, and stresses on the potential for illness, disease, or loss of functional capacity in aging adults.

The purpose of this study is to characterize worker exposure to selected pesticides in support of future medical or epidemiologic studies. A cotton defoliant, s,s,s-tributylphosphorotrithioate (DEF), was selected for study because it has been associated with delayed neurological effects. For example, the neurological effects of leg weakness and paralysis were delayed at least 14 days in hens treated with 200 mg/kg of DEF.¹ Mechanical cotton picker operators were selected as a study group because the operators were exposed to DEF and were a large enough group to form a cohort for future epidemiologic studies. In particular, the industrial hygiene data collected during this survey could be used to establish a dose-response relationship between exposure and specific health effects in future epidemiologic studies.

DESCRIPTION OF FARM, WORK FORCE, AND PROCESS

Belridge Farms consists of 18,000 acres of level farm land that must be irrigated to be productive. The farm has produced various crops which require many different farming techniques such as turning, disking, sowing, pesticide application, and harvesting. Over the years, production methods have improved and many changes have been implemented. Essentially, these improvements have meant the use of more mechanized techniques.

During this visit, only cotton picking operations were surveyed. Belridge Farms provide their own cotton picking services. Belridge Farms used ten front-mounted, closed-cab, two-row type mechanical cotton pickers to harvest cotton. During the harvesting season, about 20 non-union workers are employed as drivers, cleaner/stompers, and module operators. These workers were all men and work one shift per day which may vary from 8 to 12 hours depending on weather conditions and work schedule.

One driver operates a mechanical cotton picker. The operator will drive to the end of the field (usually $\frac{1}{2}$ section) and return, a round trip of about 1 mile in length. At the end of a round trip, the cleaner/stompers will clean the spindle guides and air intake for the blower. Also, if required, they stomp down the cotton in the basket. When the basket is full, it is emptied into a trailer for transporting to a cotton module for hydraulic pressing into a module bale, usually about 12,000 pounds. The module bale is then transported to a cotton gin for processing.

¹ Gaines, T.B.: Acute Toxicity of Pesticides. Toxicol. Appl. Pharmacol. 14:515-534 (1969).

Workers during the harvesting of cotton are exposed to many different physical and chemical agents. Physical agents include noise, vibration, UV radiation, and heat stress. Chemical exposures are usually to pesticides such as DEF, paraquat, and orethene, but there are also exposures to engine combustion products, fugitive dusts, cotton fiber, and other plant particulate matter. However, during this survey only the respiratory and dermal exposures of the operator to DEF were evaluated.

DEF, $(\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{S})_3\text{P}=\text{O}$, is a colorless to pale yellow liquid which is soluble in aliphatic, aromatic and chlorinated hydrocarbons, and alcohol solvents. DEF is registered by EPA as a cotton defoliant and is usually applied (2.25 lbs/acre) about 2 weeks prior to desired defoliation. The natural action of DEF accelerates the aging process of cotton leaves but in a relatively green state with adequate weight to cause them to fall to the ground. The cotton is usually picked 2-4 weeks after the application of DEF.

Several variables will affect the operator exposure to DEF. Variables that the operator controls are his position, position of the cab door, and the operation of the cab air filtering system. Most likely, the highest exposure would be experienced when the cab air filtering system is off, the cab door is open, and the driver is in a sitting position. Two other parameters that are important are re-entry time and application concentrations. Naturally, increasing the time interval between application of DEF and harvesting of the cotton and using the lowest concentration of DEF but still achieving defoliation will minimize exposure. Variables that cannot be controlled are temperature, radiant heat, humidity, precipitation, soil moisture content, plant moisture content, soil type, and number of pickings. Although these conditions cannot be controlled, due to the natural parameters necessary to grow cotton, most of the conditions remain relatively constant during harvesting.

Typical conditions are temperature of 55-75°F, medium to high radiant heat, low to medium humidity, occasional precipitation, low soil moisture content, sandy soil, and low plant moisture content. All of these conditions tend to promote increased exposure to DEF. Most cotton crops are picked at least twice. With all other factors remaining the same, the exposure to DEF should be less for the second picking since less airborne particulate matter is generated.

DESCRIPTION OF MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

Non-serious medical injuries of Belridge Farms employees are treated by a physician in Bakersfield, California. All serious injuries are treated at a local hospital. Employees do not receive entrance medical examinations or subsequent medical examinations except for weekly cholinesterase determinations.

An industrial hygiene program is not in effect. Environmental and personal monitoring for pesticides is not conducted. However, worker exposure to pesticides is limited by use of re-entry times. Re-entry times give the pesticides time to oxidize, hydrolyze, or evaporate, therefore reducing worker exposure. The safety program is administered by the Director of Personnel. Presently, 20 people are enrolled in the farm safety program. Approximately, 50 lost-time accidents occurred in 1977. Personnel records, which are maintained by name and social security number, include a work history and indicate any lost-time accident.

DESCRIPTION OF SAMPLING AND ANALYTICAL METHODS

Respiratory samples were collected and analyzed as described in NIOSH Sampling Data Sheet (SDS) #21 (NIOSH Manual of Sampling Data Sheets, 1977 Edition, DHEW (NIOSH) Publication No. 77-159). Basically, the sampling train consisted of a Gelman AE 37-mm glass fiber filter in a closed-face cassette, with or without a cyclone, in line with a mid-ge impinger containing ethylene glycol. The impinger was connected to a MSA Model G Pump calibrated at 1.0 liters per minute (lpm) and 1.7 lpm for total mass and respirable samples, respectively. Respiratory samples were collected inside the mechanical cotton picker cab within close proximity of the operator's breathing zone.

Dermal samples were collected to simulate deposition of DEF on the skin. Gauze pads, 4x4 inches, bonded with 1-inch tape to a polyethylene backing, 4x4 inches, were attached to the front thigh clothing area of the operators. The gauze pads collected the DEF that would have normally adhered to the clothing and penetrated to the skin. The air and dermal samples (2x2 inch center section) were extracted with benzene and analyzed by gas chromatography with a flame photometric detector as described in NIOSH Sampling Data Sheet (SDS) #21.

RESULTS AND DISCUSSION OF RESULTS

Results of respiratory and dermal sampling for DEF are reported in Tables I and II, respectively, in the Appendix. Tables 1 and 2 present a statistical summary of the results in Tables I and II, respectively. The following assumptions were made in the statistical analysis of the exposure data:

- 1) There is no significant difference in particle size distribution between respirable samples and total mass samples. Based on phase contrast microscopic examination, about 97 percent of the particles in the total mass samples were respirable (i.e. <9.5 micrometers and >1.2 micrometers in diameter).
- 2) It is valid to use for a total concentration (TC) the midpoint between "less than" and "greater than" values (e.g. $20 \leq TC \leq 30$ with the midpoint at $TC = 25$).

Table 1. Statistical Analysis of DEF Respiratory Exposure
Levels of Mechanical Cotton Picker Operators
Employed By Belridge Farms (Kern County, California)

Number of Samples	33
Highest	83.4 ng/m ³
Lowest	6.9 ng/m ³
Arithmetic Mean	21.4 ng/m ³
Standard Deviation	15.3 ng/m ³
Standard Error	2.7 ng/m ³
Geometric Mean	17.9 ng/m ³
Geometric Standard Deviation	1.77
Lower Confidence Limit	14.6 ng/m ³
Upper Confidence Limit	22.0 ng/m ³

Table 2. Statistical Analysis of DEF Dermal Exposure
Levels of Mechanical Cotton Picker Operators
Employed By Belridge Farms (Kern County, California)

Number of Samples	11
Highest	1.70 mg/8 hrs
Lowest	0.05 mg/8 hrs
Arithmetic Mean	0.28 mg/8 hrs
Standard Deviation	0.47 mg/8 hrs
Standard Error	0.14 mg/8 hrs
Geometric Mean	0.16 mg/8 hrs
Geometric Standard Deviation	2.43
Lower Confidence Limit	0.09 mg/8 hrs
Upper Confidence Limit	0.29 mg/8 hrs

- 3) It is valid to use for a total concentration below a "less than" value (e.g. $TC < 30$) the midpoint of that value and zero (i.e. $TC = 15$).

- 4) The sample data are log-normally distributed.

The 33 respiratory samples ranged from 6.9 to 83.4 nanograms of DEF per cubic meter of air sampled (ng/m^3) with a geometric mean of 17.9 ng/m^3 . An occupational respiratory exposure standard has not been established for DEF in the USA. However, about 195 pesticides have had² respiratory standards established or recommended by either ACGIH,³ OSHA, or NIOSH. The lowest standard for a pesticide is a 1 $\mu g/m^3$ ceiling³ for kepone. In the USSR a maximum allowable concentration of 200 $\mu g/m^3$ has been published for DEF.⁴ The respiratory exposure levels found in this survey are two orders of magnitude less than the lowest USA pesticide standard and four orders of magnitude less than the USSR standard for DEF.

The eleven dermal samples ranged from 0.05 to 1.70 mg/8 hours with a geometric mean of 0.16 mg/8 hours. An occupational dermal exposure standard has not been established for DEF although several pesticides have occupational exposure standards of 500 $\mu g/m^2$ (skin). The "skin" notation indicates a potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly by direct contact with the pesticide. In the case of the mechanical cotton picker operators in this survey the potential body burden is almost all dermal, i.e. 99.9%. Therefore, a standard of 500 $\mu g/m^2$ (skin) will allow an exposure via the dermal route of 5 mg/8 hours for a man breathing 10 m^3 of air during an 8-hour shift. The dermal exposure levels found are one order of magnitude less than this standard.

As previously discussed, many factors such as weather conditions can affect the level of exposure to DEF that an operator will experience. Typical weather conditions for California in the areas surveyed are temperatures in the 70-80°F range, very little precipitation, clear skies, and low humidity. However, prior to the survey there were heavy rains, and during the survey weather conditions were temperatures in the 50-60°F range, heavy fogs, cloudy skies, and high humidity. Also due to the rains, the moisture content of the plant matter and soil was high. All of these abnormal conditions were conducive to reducing exposure levels. Normal weather conditions could possibly produce exposure levels that are one or two orders of magnitude higher.

² American Conference of Governmental Industrial Hygienists

³ Occupational Safety and Health Administration

⁴ Khasanov, Yu. U. and E.N. Davletov: Hygienic Assessment of the Helicopter Method of Defoliation. Gigiena i Sanitaryi 38:103-104 (1973) (Russian).

CONCLUSIONS AND RECOMMENDATIONS

The mechanical cotton picker operators are exposed to geometric mean respiratory and dermal DEF levels of 17.9 ng/m³ and 0.16 mg/8 hours, respectively. During normal weather conditions exposure levels could be elevated by one or two orders of magnitude; therefore, additional respiratory and dermal sampling should be conducted during normal weather conditions which are conducive to higher exposure levels.

APPENDIX

Table 1. DEF Respiratory Exposure Levels of Mechanical Cotton Picker Operators Employed By Belridge Farms (Kern County, California)

Date	Sample Number	Total ng/m ³	Concentration of DEF ppt
11/15/78	RT01	<34.7	<2.7
11/15/78	RT02	13.3 ≤ TC <36.5	1.0 ≤ TC <2.8
11/15/78	RT03	<33.9	<2.6
11/16/78	RT04	7.0 ≤ TC <23.3	0.5 ≤ TC <1.8
11/16/78	RT05	<30.8	<2.4
11/16/78	RT06	<22.5	<1.8
11/17/78	RT07	25.2 ≤ TC <44.8	2.0 ≤ TC <3.5
11/17/78	RT08	7.9 ≤ TC <26.4	0.6 ≤ TC <2.1
11/17/78	RT09	<25.4	<2.0
11/15/78	RR01	<20.4	<1.6
11/16/78	RR02	<13.7	<1.1
11/17/78	RR03	<15.5	<1.2
11/15/78	RE01	<80.0	<6.2
11/15/78	RE02	<33.1	<2.6
11/16/78	RE03	9.3 ≤ TC <25.6	0.7 ≤ TC <2.0
11/16/78	RE04	46.2	3.6
11/17/78	RE05	83.4	6.4
11/17/78	RE06	15.6 ≤ TC <28.7	1.2 ≤ TC <2.2
11/15/78	ZT01	<24.8	<1.9
11/15/78	ZT02	<24.0	<1.9
11/15/78	ZT03	21.7 ≤ TC <37.2	1.7 ≤ TC <2.9
11/16/78	ZT04	13.8 ≤ TC <25.4	1.1 ≤ TC <2.0
11/16/78	ZT06	11.5 ≤ TC <23.1	0.9 ≤ TC <1.8
11/16/78	ZT06	<18.3	<1.4
11/17/78	ZT07	7.7 ≤ TC <20.6	0.6 ≤ TC <1.6
11/17/78	ZT08	8.4 ≤ TC <22.4	0.7 ≤ TC <1.7
11/17/78	ZT09	10.9 ≤ TC <24.5	0.9 ≤ TC <1.9
11/15/78	ZR01	12.8 ≤ TC <21.9	1.0 ≤ TC <1.7
11/16/78	ZR02	4.1 ≤ TC <10.9	0.3 ≤ TC <0.8
11/17/78	ZR03	6.6 ≤ TC <14.8	0.5 ≤ TC <1.2
11/15/78	ZE01	21.7 ≤ TC <37.2	1.7 ≤ TC <2.9
11/16/78	ZE02	23.1 ≤ TC <34.6	1.8 ≤ TC <2.7
11/17/78	ZE03	41.3 ≤ TC <54.2	3.2 ≤ TC <4.2

Notes:

Rotometer and standard temperature and pressure corrections have been made.

ng/m³ = Nanograms of DEF per cubic meter of air

ppt = Parts of DEF per trillion parts of air

TC = Total Concentration of DEF which is the sum of the concentrations from the filter and impinger.

Lower limit of detection was about 10 ng/sample.

Table II. DEF Dermal Exposure Levels of Mechanical Cotton Picker Operators Employed By Belridge Farms (Kern County, California)

Date	Sample Number	Total Concentration of DEF	
		$\mu\text{g}/8\text{hrs}/\text{pad}^1$	$\text{mg}/8\text{ hr}/\text{man}^2$
11/15/78	RD01-02	<0.35	<0.27
11/15/78	RD03-04	<0.43	<0.33
11/15/78	RD05	<0.41	<0.32
11/15/78	RD06	<0.41	<0.32
11/16/78	RD07	<0.15	<0.12
11/16/78	RD08	<0.11	<0.12
11/15/78	ZD01-02	<0.37	<0.29
11/15/78	ZD03-02	<0.37	<0.29
11/15/78	ZD05-06	2.19	1.70
11/16/78	ZD07	0.26	0.20
11/16/78	ZD08	0.19	0.15

¹ Micrograms of DEF per 8 hours per 2 inch x 2 inch center section of gauze pad.

² Milligrams of DEF per 8 hours per man with skin area of 2 square meters.